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Do pictures help to memorize? The influence of item presentation and executive functions on everyday memory in older adults

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Abstract: Ageing is associated with a declining memory performance. This phenomenon has been extensively investigated in different laboratory settings, while the transferability from laboratory findings to everyday life situations is rather unclear. In fact, everyday life situations have been found to enhance as well as impair older adults' memory performance. The present study deals with the question which kind of factors influence memory performance of older adults during everyday life situations. Therefore, participants (70.16 ± 5.8 years) were exposed to a supermarket scenario. Their task was to collect previously presented objects in a specified order while objects were either presented as words or pictures in correct or randomized order. Additionally, participants performed the Stroop test, Trail making test and Bochumer Matrizen test, in order to determine a possible predictability of the performance of these tasks and everyday life performance. Results showed that older adults had more problems to memorize items in the more challenging (randomized item presentation) task but presentation via pictures could offset this effect.

Subjects: Environmental Psychology; Memory; Psychological Science

Keywords: ecological validity; naturalistic task; memory; aging; item presentation; executive functions

1. Introduction

Complaints concerning declining memory performance are pretty familiar for the most of us, especially as we get older. For example, people frequently report: "I go to the store and forget what I was

ABOUT THE AUTHORS

Our research groups focuses on examining basic cognitive abilities like attention, inhibition, memory, fluid intelligence and motor learning. We try to figure out if and how age-dependent those abilities are and how they translate into everyday tasks, sports and changing environments. In previous research, we could show memory performance measured in the laboratory might not be transferable in everyday life, especially for older adults. Therefore, we are looking for factors explaining this disparity and ways to enhance memory performance in everyday life.

PUBLIC INTEREST STATEMENT

Memory is one of the most important cognitive abilities on which we rely on in our day-to-day life. It has also been one of the most focused topics in psychological research for the last decades. However, how all different laboratory findings translate into everyday life tasks is still unclear. To help to close this gap, our line of research explores memory performance in everyday life task and everyday life task settings. As previous results have shown that older adults' memory is worse in everyday tasks compared to younger adults and compared to laboratory settings, we explore possibilities to enhance memory performance in elderly. These results could lead to memory enhancing strategies, enhancing environments and intervention to support older adults in their everyday tasks.

supposed to get. I walk into a room and forget why I went in there". Within a laboratory setting, it is well established that older adults perform memory tasks worse than younger (Bäckmann, Small, & Wahlin, 2001; Hoyer & Verhaeghen, 2006; Naveh-Benjamin & Ohta, 2012; Zacks, Hasher, & Li, 2000). However, if and how those laboratory findings carry over to everyday memory performance is sparsely investigated (Verhaeghen, Martin, & Sędek, 2012). Several studies of Rendell and colleagues investigated the prospective memory performance of older adults in everyday life situations characterizing the "age-prospective memory-paradox" (Rendell & Craik, 2000; Rendell & Thomson, 1999; Rose, Rendell, McDaniel, Aberle, & Kliegel, 2010; Schnitzspahn, Ihle, Henry, Rendell, & Kliegel, 2011). This paradox describes that older adults outperform younger adults in everyday prospective memory tasks, but perform worse than younger adults in similar laboratory tasks.

To explain this distinction, previous research by Craik, Routh, and Broadbent (1983) suggests that this memory performance decline could be seen as inefficiencies of cognitive processing, rather than as true losses. Following this line of assumption (p. 350), environmental support, such as naturalistic "everyday" stimuli or task settings, could enhance cognitive processing. This might lead to a better memory performance (Bastin & Van der Linden, 2005). Due to that, memory performance of older adults should increase within a supportive environment, when using everyday cues (everyday items or pictures of them) or tasks.

In two previous studies, Kempe and colleagues transferred an episodic memory task into a naturalistic set-up to measure everyday memory performance (Kempe, Bock, & Memmert, in press; Kempe, Kalicinski, & Memmert, 2015). As naturalistic setting, they prepared a supermarket scenario where subjects were instructed to collect a list of products they previously saw on a screen. Using this setting they found a larger age-related memory performance decline compared to different laboratory memory tasks. Additionally, their results could show that everyday memory performance includes different memory systems compared to the laboratory tests.

At first view, those findings are contradictory to the age-prospective memory paradox of Rendell and colleagues (Rendell & Craik, 2000; Rendell & Thomson, 1999). However, taking a closer look both everyday life settings differed substantially. Rendell and Craik (2000) used relative simple prospective memory tasks like self-reports or board games. In contrast, the supermarket scenario can be seen as a complex everyday setting comprising the parallel use of different cognitive abilities. Besides memorizing items, participants needed to perform several parallel tasks like: a motor task (walking and grasping), visual search task (find items within the shelves), inhibition task (unrelated products), divided and selective attention task and a problem-solving task. Therefore, one can conclude, that not only the setting of a memory task, but also the complexity of cognitive demands within the setting seems to be determining older adults' performance.

Following up these results, Kempe et al. (in press) showed in a second study that the visual search and inhibition performance is impaired in older adults within the everyday memory task and that decreased inhibition but not visual search performance could predict everyday memory. Based on these results, it is probable that other basic executive functions affect everyday memory as well. To fulfil complex everyday tasks, we rely on several high-order cognitive abilities, such as fluid intelligence, planning, problem-solving, reasoning and language comprehension (Kyllonen & Christal, 1990). An age-related decline in those abilities is affiliated to four major domains, working memory, inhibitory control, processing speed and long-term memory (Rose et al., 2010). However, it remains unclear whether everyday working memory performance is influenced by different high-order cognitive abilities. Therefore, one aim of the present study is to investigate the influence of fluid intelligence (Conway, Cowan, Bunting, Therriault, & Minkoff, 2002; Kyllonen & Christal, 1990), inhibitory control (Long & Prat, 2002; Yi & Friedman, 2014) and processing speed (Salthouse, 1996) and visual attention on everyday memory performance. Therefore, we tested within this study if and in what proportion these executive functions predict everyday memory performance.

Another aspect that needs to be considered is the amount and timing of environmental support. In two previous studies (Kempe et al., 2015, in press), environmental support has been given solely during item recognition (while searching for the articles in the super market). Environmental cues during the encoding phase of the memory process might enhance the effect of the naturalistic setting (Shih, Meadmore, Liversedge, & Paterson, 2012). That is, item presentation via pictures instead of words might enhance older adults' everyday memory. The picture superiority effect is well documented within item recognition (Hockley, 2008). In a most recent study, Smith, Hunt, and Dunlap (2015) could show that younger and older adults' memory benefited from presenting pictures of items instead of words or hearing words (see also Gallo, Cotel, Moore, & Schacter, 2007).

In the present study, older adults had to memorize a list of 12 products, presented either as words or as pictures, as well as to find them within a supermarket scenario. This everyday memory task was performed with two levels of difficulty by varying the way the items were presented (serial vs. randomized). That means items which either presented in the same order as they appeared in the supermarket (serial) or in a randomized one. We expect that item presentation via pictures enhance environmental support and therefore everyday memory performance of older adults (Hockley, 2008; Smith et al., 2015). This effect should be more pronounced in the more challenging conditions (randomized item presentation) as older adults seem to have more problems manipulating stored information (Castel & Craik, 2003). Furthermore, participants had to perform tests measuring their basic executive functions to reveal their impact on everyday memory.

2. Methods

2.1. Participants

Thirty-eight older adults (71.16 ± 5.8 years, 17 male) participated in this study. All participants had to fill out a custom-made questionnaire including items on sociodemographics, health history, regular participation in sports and physical activities. In this questionnaire, all participants indicated to live independently in the community, to have normal or corrected-to-normal vision, and to be free of orthopaedic and muscular impairments. Since all participants arrived without help at the agreed-upon time in the agreed-upon place, properly followed our instructions, and correctly completed questionnaire items requiring memory and orientation (e.g. address, date of birth, medication used), we deemed them to be free of gross cognitive impairment. Each participant reported to have regularly participated in sports or other physical activities and have been a regular (minimum once per week) consumer in standard supermarkets. Written informed consent was obtained from each subject prior to participate on in this study. The study was carried out in accordance with the Helsinki Declaration of 1975 and proofed by the local ethic committee.

2.2. Apparatus, stimuli and procedure

2.2.1. Supermarket task

Nine shelves and two desks were arranged such as to create a scenario reminiscent of a corner shop. The shelves were filled with 108 different products, which were ordered in different categories (for example, milk products or canned food). Participants had to perform four shopping tasks in counterbalanced order. In each task, a shopping list with 12 products was presented as words or pictures. Each item was depicted for 3,500 ms on a computer screen, followed by a black screen for 750 ms (in total 51 s per shopping list). The products on the list were arranged either in the order as encountered when passing through the supermarket (simple order, Everyday Simple—ED-S) or in random order (Everyday Complex—ED-C). Following the presentation, participants had to walk through the supermarket and to collect all products they remembered into a shopping basket. They were instructed to pick the products in the order they passed them, which was not necessarily the order they appeared on the list. Each participant completed the tasks two times with different lists for both conditions (ED-C and ED-S). None of the items was presented twice to a participant. Previously, the supermarket was introduced by walking through and showing all products to every participant for about 15 min to create familiarity.

To measure the ED memory span (ED-S and ED-C) all products in the basket were counted, if they were part of the shopping list and if they were put into the basket at the right order. Average values of both lists were calculated for ED-C and ED-S scores (maximal possibility of 12 points) for both presentation forms (words and pictures). The order in which the four conditions of the supermarket task were completed was counterbalanced across participants.

2.2.2. Laboratory tasks

2.2.2.1. Stroop task. In order to test the participant's ability on inhibition, we conducted a modified Stroop Test (Beurskens & Bock, 2012b). Under two test conditions, the words "gelb" (yellow) and "grün" (green) were presented on a screen. Subjects were asked to respond to these stimuli by either pressing a yellow button with their right hand or a green button with their left hand as fast as possible. To keep this instruction in mind, a yellow bar was presented on the left side of the screen and a green one the right side. The colour and meaning of the words were congruent in the first and incongruent in the second condition. In the latter condition, participants had to respond in accordance with the colour if the word was presented on a black background, but in accordance with the meaning if it was presented on a light grey background. We calculated the mean reaction time RT of all 55 trials in either condition, excluding wrong responses, and used the difference between the means of congruent and incongruent condition for further analyses.

2.2.2.2. Trail making test. To test for visual attention and processing speed an enlarged of the Trail making test was used. The enlargement was done due to comparing the results with the demands when standing in front of a supermarket shelf. This test consisted of three different conditions with increasing difficulty. In the first condition, only numbers were presented randomly spread on a DIN A0 sheet mounted on a wall. The task for the participants was to mark the numbers in ascending order (Trail making A). In the second condition, numbers and letters were presented and the task was to mark them in ascending order alternating between numbers and letters (Trail making B). To measure the individual motor time subjects were instructed to mark only numbers which were presented in ascending order alternating on the upper and lower edges of a separate DIN A0 sheet in a baseline condition before starting the experiment. As parameters we measured the time subjects needed separately for Trail making A and Trail making B normed by the time needed in the baseline condition.

2.2.2.3. Bochumer Matrizen test (BOMAT). The BOMAT is a non-verbal neuropsychological test of fluid intelligence. In each trial, a 5 × 3 matrix of patterns is presented with one empty field in the matrix. The participant has to decide which pattern out of six options completes the matrix (Hossiep, Hasella, & Turck, 1999). In the conducted version, there are 29 successive matrices to complete. Due to time restrictions, participants were given 30 min to complete as many patterns as they could in each assessment session, following a 5-min introduction. The number of correct responses during this time served as a measure of fluid intelligence (Bomat-Score). Versions A and B of the BOMAT were presented randomized to the participants.

2.3. Data analysis

To analyse statistical differences with the everyday memory measures, we used a 2 × 2 (Presentation [word, picture] × Difficulty [simple, complex]) analysis of variance (ANOVA), with Presentation as the between subject factor and repeated measures on Task. Significant interaction effects were explored by Fisher LSD *post hoc* analyses. To explore influence of the basic cognitive abilities on everyday memory performance, we completed four stepwise regression analyses, one for each presentation form and task difficulty (Everyday Simple Words (ED-S-W), Everyday Complex Words (ED-C-W), Everyday Simple Pictures (ED-S-P), and Everyday Complex Pictures (ED-C-P)). As regressors the score of Bomat, RT of Stroop and the time of Trail making tasks A and B were used.

3. Results

Descriptive statistics of all conducted test for the basic cognitive abilities are summarized in Table 1. Participants could memorize on average about 66% of the presented items in the different conditions of the everyday memory task (ED-S-W, ED-C-W, ED-S-P, ED-C-P). In the more challenging complex tasks, they recognized slightly fewer items when presenting pictures (ED-C-P) and distinctly while word presentation (ED-C-W). Results of ANOVA confirmed this observation as a significant effect of task difficulty (F (1, 37) = 821.11, p < .001) as well as an interaction of Presentation x Task (F(1, 37) = 7.75, p < .01) was observed. Fisher LSD post hoc analysis of the interaction showed a significant worse performance for ED-C-W compared to all other conditions (ED-S-W: p = .00; ED-S-P: p = .00; ED-C-P: p = .00). Additionally, the performance in the simple task using word presentation was significantly worse compared to the performance in the complex task using picture presentation (p = .023). The factor item Presentation was not significant (F(1, 37) = 1.75). The outcomes of the four stepwise forward regression analyses showed mixed results. None of the regression models for both simple everyday memory tasks (words and pictures) and complex everyday memory task using picture presentation revealed a significant model fit (p > .05) and showed one of the independent variables a significant Sigma. In contrast, regression analysis of performance in the complex everyday memory task with word presentation resulted in a significant regression model including the Stroop task (Table 2). The model had a medium fit (R^2 = .11). It indicates that a faster RT in the Stroop task predicts an everyday memory performance in a complex task when presenting words.

Table 1. Descriptive analysis of all collected parameters with mean and standard deviation (Std)

	Mean	Std
ED-S-W	7.72	1.57
ED-C-W	6.57	1.95
ED-S-P	7.55	1.72
ED-C-P	7.22	1.95
Bomat	8.40	3.70
Stroop	1,070.4	408.7
Trail making A	10.79	9.80
Trail making B	55.87	32.75

Notes: Everyday memory simple word presentation (ED-S-W), Everyday memory complex word presentation (ED-C-W), Everyday memory simple picture presentation (ED-S-P) and Everyday memory complex picture presentation (ED-S-P).

Table 2. Predictors of everyday memory with complex item presentation (word) with *B*—regression coefficient, SE—standard error of *B* and Sig—significance value of *B*

	Everyday memory performance (word-complex)		
	B	**SE**	**Sig**
Constant	8.23	.86	.000
Stroop	−.33	.16	.046
Bomat	0.09	.09	.562
Trail making A	0.12	.11	.456
Trail making B	0.01	.09	.538

Notes: R^2 = .106, p < .05.

4. Discussion

This study delineated factors that influence everyday memory performance in older adults. Participants had to perform a simple and a complex memory task within a shopping scenario using either words or pictures for item presentation in order to manipulate environmental support. In line with previous findings on everyday memory (Kempe et al., 2015, in press) and laboratory memory tasks (Castel & Craik, 2003); older adults' memory performance was decreased in the complex task, when items had to be manipulated before item recognition. However, post hoc analysis revealed that this was only true for word but not for picture presentation. When presenting words, participants recognized significant fewer items in the complex task in comparison to the other conditions of the supermarket task. In contrast, everyday performance was stable when presenting items in a more "environmental supportive" manner (pictures). Those results are in accordance with Smith et al. (2015); who could show that picture presentation reduced older adults' false memory compared to word presentation (see also Gallo et al., 2007). Furthermore, our results reaffirm the picture superior effect (Hockley, 2008) within a naturalistic task.

The emergence of the picture superior effect in the more demanding task is supporting the hypothesis that a decline in memory performance might be related to inefficient processing (Craik et al., 1983) rather than true losses of cognitive resources. In the complex shopping task, participants had to rearrange items in their mind before retrieval. During this manipulation older adults seem to have more problems to retain to be remembered information. Bastin and Van der Linden (2005) could show that the human information processing systems optimizes the processing of task relevant information and that task-related stimuli enhance information processing. By presenting task-related, naturalistic stimuli (pictures) instead of words it might be easier for older adults to bind information within the actual shopping task and therefore sustain their everyday memory performance.

Following the idea of the picture superior effect, one would also expect a better performance in the simple task with picture presentation compared to the simple task with word presentation. However, this might be a ceiling effect as other cognitive abilities or parallel tasks interfere with the memory process. To examine this possibility, we calculated analysis if cognitive basic abilities predict everyday memory via regression. Regression analysis with Bomat-Score, RT of the Stroop task and times for Trail making tasks A and B as independent variables showed mixed results. Bomat was not included in neither of the regression models. Therefore, fluid intelligence does not seem to predict everyday memory performance. Given previous research, we suspected that fluid intelligence might be a predictor in the complex task setting when items had to be rearranged (Kyllonen & Christal, 1990). However, memory processing might be a more basic procedure and therefore predict fluid intelligence, but not vice versa (Conway et al., 2002).

Surprisingly, the Trail making task did not yield any predictive power for everyday memory as well. Processing speed is seen as one of the most important influencing factors in laboratory memory tasks (Conway et al., 2002; Unsworth, Redick, Heitz, Broadway, & Engle, 2009), especially in complex tasks. A possible explanation of this finding might be that participants had no time constraints to fulfil the shopping task. In accordance with everyday life, participants were instructed to perform the memory task as best not as fast as possible. Therefore, processing speed might play a rather subordinate role.

The Stroop task RT was the only one of the basic cognitive abilities to predict everyday memory, albeit only for the complex everyday memory task with word presentation. To inhibit irrelevant information during item encoding and recognition has been revealed as important factor in previous research (Long & Prat, 2002; Yi & Friedman, 2014). Kempe et al. (in press) could also show that Stroop performance predicts memory performance, using word presentation, in the supermarket task. However, within their study Stroop performance has been a predictor on both task difficulties which might be due to different regression model used in this. The emphasized influence of inhibition in the complex task is in line with our hypothesis that parallel processing is adherent in complex

everyday task. More important, inhibition was no predictor in the complex memory task using picture presentation. This finding is in accordance with our previous suggestion that picture presentation is helpful during item recognition. Because of the presentation via pictures participants might have a clearer image of to be found items in mind.

To conclude, the current study could show that older adults have more problems in an everyday memory task if the task is more complex. To inhibit irrelevant information seems to be a major limiting factor in these more complex tasks. However, additional environmental support, via picture presentation, during item encoding seems to reduce this effect. These findings suggest that older adults' everyday memory benefits if environmental supportive and task-related items are presented.

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